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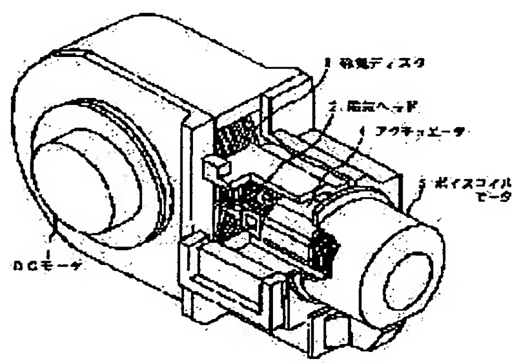
## (54) MAGNETIC STORAGE DEVICE AND THIN-FILM MAGNETIC HEAD USED FOR THE SAME AND ITS PRODUCTION

(57)Abstract:
PURPOSE: To obtain a magnetic head for a high recording density in a high-frequency region, i.e., for dealing with a high speed access and high-speed transfer by specifying the material of a magnetic core for writing of a thin-film magnetic head and a magnetic storage device using the same.
CONSTITUTION: This device consists of a thin-film magnetic disk 1 for recording information, a DC motor for rotating this magnetic head 1, the thin-film magnetic head 2 for writing and reading the information, an actuator 4 for supporting this disk and accessing the thin-film magnetic disk 1, a voice coil motor 5, etc. At least either of the upper magnetic core and lower magnetic core of the thin-film magnetic head 2 are formed by using magnetic metallic materials having an average crystal grain of ≤500Å, specific resistance of ≥40μΩcm at room temp. and coercive force of ≤1.0Oe in a difficult axis direction. As the result, the high-speed transfer of the data, the shorter access time and the greater recording capacity are made possible to be obtained.

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CLAIMS

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[Claim(s)]
[Claim 1] The thin film magnetic disk which records information, and the rotation means of this thin film magnetic disk, In the magnetic storage possessing the thin film magnetic head which is prepared in a float-type slider and performs writing and read-out of information, and a move means to support the aforementioned float-type slider and to access to a thin film magnetic disk For the specific resistance of 500A or less and a room temperature, the coercive force of 40 or more microomegacm and difficult shaft orientations is [ either / at least / the up magnetic core of the aforementioned magnetic core for writing of the aforementioned thin film magnetic head, or a lower magnetic core / the diameter of average crystal grain ] 1.0Oe(s). From the metal magnetism material which is the following, a bird clapper Magnetic storage by which it is characterized.
[Claim 2] The thin film magnetic disk which records information, and the rotation means of this thin film magnetic disk, In the magnetic storage possessing the thin film magnetic head which is prepared in a float-type slider and performs writing and read-out of information, and a move means to support the aforementioned float-type slider and to access to a thin film magnetic disk Either [ at least ] the up magnetic core of the aforementioned magnetic core for writing of the aforementioned thin film magnetic head or a lower magnetic core is the magnetic storage characterized by the bird clapper from the electroplating thin film of a nickel-Fe system alloy which has 38 - 60 % of the weight of nickel, and 40 - 62 % of the weight of Fe(s) by the weight.
[Claim 3] In the magnetic storage in which the storage of 500 megabits or more per 1 square inch and information possessed [ the media transfer rate / the field recording density of 15 megabytes or more per for 1 second, and record data ] the disk-like magnetic disk with a diameter of 3.5 inches or less The aforementioned magnetic disk is 4000rpm at the time of record and reproduction. The thin film magnetic head which it rotates above, and record frequency is 45MHz or more, and performs the aforementioned record at least an up magnetic core It consists of a nickel-Fe system alloy which has 38 - 60 % of the weight of nickel, and 40 - 62 % of the weight of Fe(s) by the weight. For 500A or less and specific resistance, the coercive force of 40 - 60microomegacm and difficult shaft orientations is [ the thickness / 1-5 micrometers and the diameter of average crystal grain ] 1.0Oe(s). The record magnetomotive force of the following and this magnetic head for record is 0.5. Magnetic storage characterized by being more than an amp turn.
[Claim 4] The thin film magnetic disk which records information, and the rotation means of this thin film magnetic disk, In the magnetic storage possessing the thin film magnetic head which is prepared in a float-type slider and performs writing and read-out of information, and a move means to support the aforementioned float-type slider and to access to a thin film magnetic disk The aforementioned magnetic disk is 4000rpm at the time of record and reproduction. It rotates above. It consists of a nickel-Fe system alloy of the thin film magnetic head which record frequency is 45MHz or more, and performs the aforementioned record with which an up magnetic core at least has 38 - 60 % of the weight of nickel, and 40 - 62 % of the weight of Fe(s) by the weight. Magnetic storage to which the thickness is characterized by the coercive force of 40 - 60microomegacm and difficult shaft orientations being [ 1-5 micrometers and the diameter of

average crystal grain / the record magnetomotive force of 1.0 or less Oes and this magnetic head for record ] 0.5 or more amp turns for 500A or less and specific resistance.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention relates to the head for record of record / reproduction discrete-type magnetic head for high recording density about the magnetic core for the magnetic heads.
[0002]
[Description of the Prior Art] In recent years, with the raise in the recording density of a magnetic disk unit, high coercive force-ization of a record medium progresses and the thin film magnetic head which has the capacity which can be enough recorded on this high coercive force medium is demanded. For that purpose, it is required for the core materials of the magnetic head to use a high material of saturation magnetic flux density (BS). As such material, the nickel-Fe alloy film whose thickness is about 3 micrometers has been used conventionally. However, for a 16 - 20microomegacm and low reason, eddy current loss has [ this nickel-Fe alloy film ] large specific resistance, for this reason, the record magnetic field strength in a RF field falls, and at most about 30MHz of record frequency is a limit. Moreover, although Co system amorphous materials, the Fe-aluminum-Si system SENDATO alloy thin film, etc. are proposed as a material replaced with this and the former is amorphous therefore, since a thermally unstable thing and the latter need heat treatment at the high temperature of about 500 degrees C, they have a difficulty in manufacture process as magnetic-core material for magnetic disks, and have not resulted in utilization. Moreover, recently, the Co-nickel-Fe system material of 3 yuan is proposed as a magnetic-core material for the thin film magnetic heads (JP,60-82638,A, JP,61-76642,A, JP,64-8605,A, JP,2-68906,A, JP,2-290995,A).
[0003]
[Problem(s) to be Solved by the Invention] For such 3 yuan system material, saturation magnetic flux density (BS) is 1.5T. The above was not considered at all about specific resistance and the diameter of crystal grain like the nickel-Fe alloy film, although it was high, but the difficulty was in the RF property still like the nickel-Fe alloy film.
[0004] 3.5 which the storage capacity of a magnetic disk unit is increasing certainly every year, and is produced commercially on the other hand now the field recording density of inch equipment, and the maximum -- 350Mb/inch2 up to -- it is raised The data-logging frequency in this case is about 27MHz, and is approaching the performance limit of the magnetic head by a conventional nickel-Fe alloy film or a conventional Co-nickel-Fe alloy film.
[0005] Moreover, although JP,3-68744,A is proposed as a magnetic film formed in 40 - 55 nickel-Fe as an object for RFs by the sputtering method which added Nb, Ta, Cr, Mo, etc., the thick-film formation by the sputtering method is difficult in magnetic properties because of material with a large crystal magnetic anisotropy.
[0006] The purpose of this invention is to offer the magnetic storage which used the object for the high recording density in a RF field, i.e., rapid access, the magnetic head dealing with fast transmission, and this.
[0007]
[Means for Solving the Problem] The magnetic disk unit for having accomplished this invention in

view of the problem mentioned above, and making fast transmission and high recording density attain, Namely, for a magnetic disk unit, a magnetic disk is 4000rpm at the time of record and reproduction. It rotates above. It carries in the magnetic storage by which record frequency is set as 45MHz or more, and as the thin film magnetic head for demonstrating the performance, saturation magnetic flux density (BS) is large, and material with large specific resistance is required small [ the coercive force of difficult shaft orientations ]. Therefore, specific resistance is also high and the range of the composition field where saturation magnetic flux density is also high is nickel:38-60 % of the weight. However, membranous crystal grain becomes large, this composition field has large coercive force, when producing the magnetic film of the thick film 2 micrometers or more usually applied to the thin film magnetic head etc. by the sputtering method etc., since a crystal magnetic anisotropy is the largest range, and a uniaxial anisotropy is hard to give.
[0008] Then, take up the galvanizing method for the ability to stop crystal grain small, and addition of the 3rd element, such as Co, Mo, Cr, Pd, B, and In, is considered 38 to 60% of the weight based on the nickel-Fe system alloy of 2 yuan. The outstanding composition range and the outstanding manufacture method of a thin film of being after securing 2-5 micrometers of thickness which acquires a required record magnetic field, being more than saturation-magnetic-flux-density (BS):1.5T and less than [ coercive force (HCH):1.0Oe ], and having 40 or more microomegacm of specific resistance are found out. By using such material for the thin film magnetic head, it is field recording density:500Mb/inch2. The highly efficient magnetic storage of more than record frequency:45MHz and 15 or more MB/s of transfer rates can be offered above.

[0009] The thin film magnetic disk with which this invention records information, and the rotation means of this thin film magnetic disk, In the magnetic storage possessing the thin film magnetic head which is prepared in a float-type slider and performs writing and read-out of information and which performs especially these separately, and a move means to support the aforementioned float-type slider and to access to a thin film magnetic disk For the specific resistance of 500A or less and a room temperature, the coercive force of 40 or more microomegacm and difficult shaft orientations is [ either / at least / the up magnetic core of the aforementioned magnetic core for writing of the aforementioned thin film magnetic head, or a lower magnetic core / the diameter of average crystal grain ] 1.0Oe(s). From the metal magnetism material which is the following, a bird clapper It is in the magnetic storage by which it is characterized.
[0010] Furthermore, this invention is characterized by the bird clapper from the electroplating thin film of the nickel-Fe system alloy with which either [ at least ] the up magnetic core of the aforementioned magnetic core for writing of the aforementioned thin film magnetic head or a lower magnetic core has 38 - 60 % of the weight of nickel, and 40 - 62 % of the weight of Fe(s) by the weight.
[0011] Furthermore, for the field recording density of 15 megabytes or more per for 1 second, and record data, the storage of 500 megabits or more per 1 square inch and information is [ this invention / a media transfer rate ] a diameter 3.5. In the magnetic storage possessing the disk-like magnetic disk below an inch The aforementioned magnetic disk is 4000rpm at the time of record and reproduction. The thin film magnetic head which it rotates above, and record frequency is 45MHz or more, and performs the aforementioned record at least an up magnetic core It consists of a nickel-Fe system alloy which has 38 - 60 % of the weight of nickel, and 40 - 62 % of the weight of Fe(s) by the weight. For 500A or less and specific resistance, the coercive force of 40 - 60microomegacm and difficult shaft orientations is [ the thickness / 1-5 micrometers and the diameter of average crystal grain ] 1.0Oe(s). The record magnetomotive force of the following and this magnetic head for record is 0.5. It is characterized by being more than an amp turn.
[0012] The aforementioned magnetic core concerning this invention can contain one or more sorts of 15 or less % of the weight of Co(es), and Mo, Cr, Pd, B and In by the weight, and can contain at least 3 or less % of the weight of one side in a total amount.
[0013] Furthermore, this invention is characterized by to use the same property as the above-

mentioned, and the thing of composition for the magnetic film of the thin film magnetic head of the above-mentioned Records Department also in the magnetic storage possessing the thin film magnetic disk which records information, the rotation means of this thin film magnetic disk, the record reproduction discrete-type thin film magnetic head which is prepared in a float-type slider and performs writing and read-out of information with a separate element, and a move means support the aforementioned float-type slider and access to a thin film magnetic disk.

[0014] Furthermore, for the field recording density of 15 megabytes or more per for 1 second, and record data, the storage of 500 megabits or more per 1 square inch and information is [ this invention / a media transfer rate ] a diameter 3.5. In the magnetic storage possessing the disk-like magnetic disk below an inch The aforementioned magnetic disk is 4000rpm at the time of record and reproduction. It rotates above. Record frequency is 45MHz or more, and it has the record reproduction discrete-type thin film magnetic head which performs the aforementioned record reproduction with a separate element, and is characterized by using the property as an up magnetic core of the thin film magnetic head same at least of performing the aforementioned record, and the thing of composition.

[0015] this invention is formed on a lower magnetic film and this lower magnetic film, and an end touches the end of the aforementioned lower magnetic film. The up magnetic film which forms the magnetic circuit which the other end counters the other end of the aforementioned lower magnetic film through a magnetic gap, and has a magnetic gap in part with a lower magnetic film by this, In the thin film magnetic head possessing the coil between both magnetic films -- a passage -- a magnetic circuit -- crossing -- predetermined -- winding -- a number -- the conductor which forms a coil -- Either [ at least ] the aforementioned lower part or an up magnetic film is formed by the galvanizing method. It consists of a nickel-Fe system alloy which contains 38 - 60 % of the weight of nickel, and 40 - 62 % of the weight of Fe(s) by the weight, and, for 1-5 micrometers and the diameter of average crystal grain, the coercive force of 500A or less and difficult shaft orientations is [ thickness ] 1.0Oe(s). It is in the thin film magnetic head characterized by being the following.

[0016] this invention is formed on a lower magnetic film and this lower magnetic film, and an end touches the end of the aforementioned lower magnetic film. The up magnetic film which forms the magnetic circuit which the other end counters the other end of the aforementioned lower magnetic film through a magnetic gap, and has a magnetic gap in part with a lower magnetic film by this, In the manufacture method of the thin film magnetic head of having provided the coil between both magnetic films -- a passage -- a magnetic circuit -- crossing -- predetermined -- winding -- a number -- the conductor which forms a coil -- A plating bath contains either [ at least ] the aforementioned lower part or an up magnetic film, and metal ion concentration contains the nickel++ ion of 15 - 20 g/l, and the Fe++ ion of 2.0 - 2.7 g/l. And 7-8, the ratio (nickel++/Fe++) of nickel++ ion and Fe++ ion It is in the manufacture method of the thin film magnetic head characterized by forming by electroplating using the electroplating bath of the nickel-Fe alloy whose pH is 2.5-3.5 including a stress relaxation agent and a surfactant. It holds at 20-35 degrees C, and especially the degree of bath temperature is 5 - 30 mA/cm2. It is desirable to produce with the frame plating in a magnetic field with current density.

[0017] Furthermore, this invention is each ion of 0.4 - 0.6 g/l, and Cr, Mo, Pd, In and B about Co ion 0.1 g/l It is characterized by adding the following. Furthermore, as for this invention, it is desirable to produce by electroplating with the frame in a magnetic field.

[0018] this invention is solved by rotating the magnetic disk which designed thickness, specific resistance, and relative permeability in consideration of eddy current loss of the magnetic pole magnetic film of a recording head, and set the record frequency of data as writing and preventing change of the amount of bleeding, or an over-writing value and the row in accordance with record frequency highly, and fitted the above-mentioned head at high speed.

[0019] (1) It is desirable that a media transfer rate has a means by which the field recording density of 15 megabytes or more per for 1 second and record data becomes 500 megabits or more per 1 square inch.

[0020] (2) It is a diameter 3.5 about informational storage. When carrying out to the magnetic disk of the shape of a disk below an inch, this magnetic disk is 4000rpm at the time of record

reproduction. It is desirable that rotate above and record frequency is set as 45MHz or more.
[0021] (3) It is desirable to have a magnetic disk using the metal magnetic film of 2 or more kOes of coercive force.
[0022] (4) It is desirable that the rise time of record current is set below to 5 nanoseconds (ns).
[0023] (5) The coil for record of the induction-type magnetic head which records information on a magnetic-disk medium is formed using the thin film process, the number of terminals is 3 and, as for the inductance between each terminal, it is desirable that it is below a 1micro henry (muH).
[0024] (6) The coil for record of the induction-type magnetic head which records information on a magnetic-disk medium is two-layer structure, the number of coils of the 1st layer coil and a two-layer eye coil is equal, and, as for the direction of a coil, it is desirable that it is a retrose mutually.
[0025] (7) The coil for record of the induction-type magnetic head which records information on a magnetic-disk medium is one layer structure, another terminal is connected to the position (c) which is equivalent to the half of the number of coils between terminal points (b) from the coil starting point (a), and, as for the current which flows between (c)-(a) and between (c)-(b), it is desirable that it is an opposite phase mutually.
[0026] (8) When relative permeability [ in / rho (microomegacm) and a low frequency field / the thickness of the magnetic film which constitutes record of data or the record magnetic pole of the magnetic head used for record reproduction and / for specific resistance ] is set to mu, each parameter is mud2/rho<=500. It is desirable to have a means to satisfy a relation. / d (micrometer)
[0027] (9) A part of record of data or record magnetic pole [ at least ] of the magnetic head used for record reproduction has multilayer structure to which the laminating of a magnetic layer and the insulating layer was carried out by turns, and the thickness is 2.7 micrometers. It is desirable that it is the following.
[0028] (10) It is desirable that Co system amorphous alloy or Fe system amorphous alloy uses at the Fe-nickel system alloy [ of the magnetic material for record ] of at least the above-mentioned [ material / up magnetism ] of the magnetic head used for record of data or record reproduction and the lower part.
[0029] (11) In the record magnetic pole material of the magnetic head, the thing of Zr, Y, Ti, Hf, aluminum, or the Si included for a kind at least is desirable.
[0030] (12) It is desirable that the product with record of data or the record magnetomotive force of the magnetic head used for record reproduction, i.e., record current, and the number of coil coils is set up more than 0.5 amp turns (AT).
[0031] (13) It is desirable that a part of [ at least ] specific resistance of record of data or the record magnetic pole of the magnetic head used for record reproduction is 40 or more microomegacm, and relative permeability is 500 or more.
[0032] (14) The coil for record of the induction-type magnetic head which records information on a magnetic-disk medium is one layer structure. The current which another terminal is connected to the position (c) equivalent to the half of the number of coils between terminal points (b) from the coil starting point (a), and flows between (c)-(a) and between (c)-(b) is an opposite phase mutually, It is desirable to use the record reproduction discrete-type head using the spin bulb type element and the huge magnetoresistance-effect type element as the reproducing head.
[0033]
[Function] In a RF field with a record frequency of 45MHz or more, as for the head efficiency (efficiency which guides magnetic flux) of the magnetic head, eddy current loss becomes dominant. Therefore, although it is most effective to make thickness of a magnetic core thin in order to mitigate eddy current loss, if thickness is made thin, record magnetic fields will run short and it will become unrecordable. Coercive force: 2000 or more Oes, in order to record on the high coercive force medium of 2300 or more Oes enough especially, as for thickness, 2 micrometers or more are needed not to mention saturation magnetic flux density being high. Usually, although it is for reducing this eddy current loss, it is difficult in the head process

dealing with high recording density in dimensional accuracy to multilayer-ize. Therefore, it is required to enlarge specific resistance of a magnetic core, to reduce eddy current loss, and to lengthen the frequency characteristic of the permeability (mu) of a magnetic core to a RF side.
[0034] In the nickel-Fe system magnetic film (thickness : 3 micrometers) of 2 yuan, saturation magnetic flux density (BS) is 1.5T at the range of 38 - 60 % of the weight of nickel. While the above is shown, specific resistance (rho) shows 40 - 50microomegacm. That is, although specific resistance (rho) is high when nickel becomes less than 38 % of the weight, saturation magnetic flux density (BS) is 1.5T. It turns the bottom. Moreover, if nickel exceeds 60 % of the weight, saturation magnetic flux density (BS) is 1.5T too. Since it turns the bottom, it is not desirable. Especially, 40 - 50 % of the weight is desirable. The galvanizing method is good when producing the film of such composition. That is, it is because coercive force's being made small also in this large composition of a crystal magnetic anisotropy in order to make the diameter of crystal grain very detailed with electroplating, and the stacking tendency of a crystal can be lost as much as possible. For example, it is the orientation ratio of a crystal (111) / (200) <5.0 It is desirable to make it below. nickel and Fe ion concentration of plating bath composition for producing such a film were nickel++:15 - 20 g/l and Fe++:2.0 - 2.7 g/l, and ion ratios (nickel++/Fe++) were 7-8. Moreover, the plating-current density at this time is [ 3.0 and the degree of bath temperature of 10 - 20 mA/cm2 and pH ] 30 degrees C.
[0035] It is desirable, when adding at least one sort of elements of Co, Mo, Cr, B, In, and Pd, and Co maintains saturation magnetic flux density (BS) 15 or less % of the weight, as for Mo, 3 or less % of the weight maintains it more than 1.5T and 40 or more microomegacm are secured for specific resistance (rho) on the other hand. In Co, in the case of Mo, addition to 4.8 g/l (it is 1.9 g/l at Mo ion) is [ O / CoSO4.6H2] desirable in Na2MoO4.2H2O at bath composition to 100 g/l (it is 21 g/l at Co ion). For example, it is Cr [Cr2(SO4) 3.18H2O] instead of Mo. When it added, the almost same result was shown. There was no effect at about 10% that B, In, etc. of increase of specific resistance (rho) were so big. Although addition of Co falls a little, since saturation magnetic flux density (BS) increases about 10%, membranous specific resistance (rho) has the common use desirable [ on the other hand, ] with Mo. Moreover, since Co makes a membranous anisotropy field (HK) increase, it is desirable to stabilization of magnetic properties.
[0036] In addition, if Co becomes 15% of the weight or more, although membranous saturation magnetic flux density (BS) increases, specific resistance (rho) will become small too much, and unless it makes [ many ] the addition of Mo and Cr, it cannot do greatly to the value of a request of membranous specific resistance (rho). Therefore, membranous coercive force becomes large and is not desirable. Moreover, in order [, such as Mo and Cr, ] to enlarge to the value of a request of specific resistance (rho) without already enlarging coercive force of a beam film, you may be 3 or less % of the weight.
[0037] Moreover, the same is said of additions, such as B, In, and Pd. The plating conditions in these cases are completely the same as that of the case of an above-mentioned nickel-Fe system of 2 yuan, and are good.
[0038] If RF loss (tandelta) of a magnetic film assumes that it is what is depended only on eddy current loss tandelta=mu"/mu' =R/omegaL =mu0micropid2f/Crho -- (1)
It can express. Here, mu' and mu" are the real parts and imaginary parts of complex permeability, respectively. Moreover, C is the constant decided by the film configuration, and mu 0. It is space permeability. Eddy current loss tandelta to frequency f if an upper formula (1) shows the relative permeability mu peculiar to a magnetic film, Thickness d, and specific resistance rho It can estimate. In addition, since the change of head efficiency (efficiency which guides magnetic flux) to frequency is considered to be proportional to change of the real part of complex permeability, it computes delta from (1) formula, and it is this cos. It can ask for the frequency dependence of head efficiency by taking a component. That is, the head efficiency eta in each frequency can be expressed with the following formula.
[0039]
Eta=cos [arctan (mu0micropid2f/Crho)] -- (2)
(2) mud2/rho which is the value which can be found from a formula by the relative permeability mu peculiar to a magnetic film, Thickness d, and specific resistance rho By specifying a value,

the head efficiency eta in the arbitrary frequency f can be extrapolated.
[0040] Field recording density is 2 500 Mb(s)/inch by writing at the time of the above-mentioned head and RF record, bleeding and combining with the magnetic disk using the metal magnetic film of 2 or more kOes of small coercive force of over-writing change. The highly efficient magnetic disk unit of the record frequency of 45MHz or more and 15 or more MB/s of media transfer rates is obtained above.
[0041] When a data bus uses Fast and Wide SCSI (Samll Computer System Interface) of 2 BAIDO width of face for an I/O interface, if a data bus uses the Fast and Wide SCSI interface of 2 BAIDO width of face, the data transfer of a maximum of 20 MB/s will become possible from the relation between the price of an I/O device, and the transfer rate per [ which constitutes an I/O device ] magnetic disk unit. In this case, if the transfer rate per magnetic disk unit is 15 or more MB/s, it understands a bird clapper as price reduction of an I/O device being possible.
[0042] Moreover, the capacity per magnetic disk unit will be Windows if there is 550MB. It becomes possible to deal with OS's (Operation Software), such as Workplace. This capacity is 3.5. In order to realize with one magnetic disk of an inch, the field recording density which can record data is 2 500 Mb(s)/inch. It is necessary to be above.
[0043]
[Example]
(Example 1) The general drawing of the magnetic disk unit which is an example of this invention, and a plan are shown in drawing 1 and drawing 2 . The composition of this magnetic disk unit consists of an air filter 6 for keeping pure the magnetic head 2 for writing in, reading and carrying out the magnetic disk 1 for recording information, the DC motor (drawing ellipsis) turning around this of a means, and information and the pointing device of a means to change a position to a magnetic disk in support of this, i.e., an actuator 4 and the voice coil motor 5, and the interior of equipment etc. An actuator consists of carriage 7, a rail 8, and bearing 9, and a voice coil motor consists of a voice coil 10 and a magnet 11. The magnetic disk of eight sheets is attached in the same axis of rotation, and these drawings show the example which enlarged total storage capacity.
[0044] Similarly the front view of the magnetic recorder and reproducing device which drawing 3 requires for this invention, and drawing 4 are the plan. For 1, as for the magnetic head and 3, in drawing, a magnetic disk and 2 are [ gimbal system means for supporting and 4 ] pointing devices (actuator). The rotation drive of the magnetic disk 1 is carried out in the direction of Arrow a by the rotation drive. It is supported by means for supporting 3 and the magnetic head 2 is the rotation diameter O1 by the pointing device 4. In a top, it is an arrow b1. Or b2 It is driven and positioned in a direction and is predetermined cylinder T1 -Tn by it. It sets and magnetic recording and reproduction are performed.
[0045] A magnetic disk 1 is surface roughness RMAX. It considers as 100A or less and the desirable good medium of front-face nature 50A or less. The magnetic disk 1 has formed the magnetic-recording layer in the front face of a rigid base by the vacuum forming-membranes method. A magnetic-recording layer is formed as magnetic thin films, such as gamma-Fe 2O3 or Co-nickel, and Co-Cr. The thickness of the magnetic-recording layer formed by the vacuum forming-membranes method is 0.5 micrometers. Since it is the following, the front-face nature of a rigid base is reflected as front-face nature of a record layer as it is. Therefore, a rigid base is surface roughness RMAX. A thing 100A or less is used. As such a rigid base, the rigid base which makes a principal component glass, the soda alumino silica glass by which the chemical strengthening was carried out, or a ceramic is suitable. A magnetic-recording layer can consist of the magnetic oxides of iron and the magnetic nitrides of gamma-Fe 2O3 grade. Moreover, it is desirable in the case of a metal, an alloy, etc., for a magnetic layer to prepare an oxide layer and a nitride layer in a front face, or to use a front face as an oxide film. Moreover, use of a carbon protective coat etc. is desirable. By carrying out like this, the endurance of a magnetic-recording layer improves and the injury on a magnetic disk 1 can be prevented at the case where record reproduction is carried out by the ****** flying height, and the time of contact, a start, and a stop. An oxide layer and a nitride layer can be formed by the reactant spatter, reactant vacuum evaporationo, etc. Moreover, by reactant plasma treatment etc., an oxide film oxidizes

intentionally and can form the front face of the magnetic-recording layer which becomes like Co-nickel or Co-Cr with the metal or alloy containing at least one sort in iron, cobalt, and nickel. Magnetic disks 1 may be any of the vertical recording to which the record residual magnetization of a magnetic-recording layer makes a vertical component a principal component to a film surface, and the record within a field which makes the component in a film surface a principal component. Although illustration was omitted, you may apply lubricant to the front face of a magnetic-recording layer.

[0046] Drawing 5 and drawing 6 are drawings showing the prefabricated frame structure of the magnetic head 2 and the gimbal system means for supporting 3. The magnetic head 2 makes the R/W element 22 adhere to the airstream appearance edge side of the slider 25 which becomes by the ceramic structure, and it is supported so that a load may be added to the field 24 of an opposite side in the surfacing side 23 and pitch movement and roll movement may be permitted by the means for supporting 3 driven with a pointing device 4. The R/W element 42 is a thin film formed according to the same process as IC manufacture technology.

[0047] Means for supporting 3 have structure which attached the flexible body 36 which is a sheet metal as well as the free end in the end of the longitudinal direction of a base material 37, and attached the magnetic head 2 in the inferior surface of tongue of this flexible body 36 while they attach the end of a base material 37 which becomes by the elastic metal thin film in the rigid arm section 51 attached in a pointing device 4 with the joint implements 11 and 12 and fix to it (refer to drawing 3 and drawing 4 ). The portion attached in the rigid arm section 51 serves as the elastic spring section 21, it connects with this elastic spring section 41, and the base material 37 has formed the rigid beam section 42. The rigid beam section 42 has the flanges 42a and 42b bent and formed in both sides. Two outside flexibility **** 31 and 32 which a flexible body 36 carries out abbreviation parallel with the longitudinal direction axis of a base material 37, and are extended, The horizontal frame 33 which connects outside flexibility **** 31 and 32 in the edge distant from the base material 37, It has the central tongued section 34 which has been extended so that abbreviation parallel may be carried out from the abbreviation center section of the horizontal frame 33 at outside flexibility **** 31 and 32, and used the nose of cam as the free end, and is constituted, and the direction with the horizontal frame 33 has attached the end of an opposite side near the free end of a base material 37 by meanses, such as welding.

[0048] The semi-sphere-like etc. salient 35 for loads is formed in the upper surface of the central tongued section 34 of a flexible body 36, and the load is told to it from the free end of a base material 37 to the central tongued section 34 by this salient 35 for loads. In the inferior surface of tongue of the central tongued section 34, the field 24 of the magnetic head 2 is fixed by meanses, such as adhesion.

[0049] It sets to this example and is above-mentioned surface roughness RMAX. The magnetic disk 1 which it has is used and the surfacing start flying height of the magnetic head 2 is set as the range of 0.01 micrometers - 0.04 micrometers. and R/W cylinder T1 -Tn prepared in a magnetic disk 1 the flying height g of the magnetic head 2 in inside and the most-inner-circumference cylinder Tn -- 0.01 micrometers - 0.04 micrometers of surfacing start flying heights from -- it sets up and drives between one several times the value of this The rotational frequency of the configuration of the slider 21 which constitutes the magnetic head 2, the load which joins the magnetic head 2 from means for supporting 3, and a magnetic disk 1 etc. is set up so that the above flying heights may be obtained.

[0050] Drawing 7 is the perspective diagram of a negative pressure slider.

[0051] The load slider 70 has the negative pressure generating side 73 surrounded by the air introduction side 71 and two positive pressure generating sides 72 and 72 which generate buoyancy, and consists of slots 74 where a level difference is larger than the negative pressure generating side 73 on the boundary of the air introduction side 71 and two positive pressure generating sides 72 and 72, and negative pressure generating sides 73 further. In addition, in the air defluxion edge 75, it has the thin film magnetic-head element 76 which performs informational record reproduction to a magnetic disk.

[0052] Although the air introduced from the air introduction side 71 at the time of surfacing of the negative pressure slider 70 expands in respect of [ 73 ] negative pressure generating, since

the flow of the air which goes to a slot 74 in that case is also made, the flow of the air which goes to the air defluxion edge 75 from the air introduction side 71 exists also in the interior of a slot 74. Therefore, though the dust which floats in air is introduced from the air introduction side 71 at the time of surfacing of the negative pressure slider 70, it will be introduced inside a slot 74, and it will be washed away by the flow of the air of the slot 74 interior, and will be discharged out of the negative pressure slider 70 from the air defluxion edge 78. Moreover, since the flow of air always exists in the slot 4 interior at the time of surfacing of the negative pressure slider 70 and there is no stagnation etc., dust does not condense.

[0053] Drawing 8 is the conceptual diagram of the record reproduction discrete-type head in which the head for record was formed. A record reproduction discrete-type head consists of the shield section for preventing derangement of the reproducing head by the recording head of the inductive mold which used the element of this invention, the reproducing head, and the leakage magnetic field. Although here showed loading with the recording head for level magnetic recording, the magnetoresistance-effect element of this invention may be combined with the head for vertical magnetic recordings, and may be used for vertical recording. A head comes to form the lower shield film 82, the magnetoresistance-effect film 86 and an electrode 85, the reproducing head that consists of an up shield film 81, and the recording head which consists of the lower magnetic film 84, a coil 87, and an up magnetic film 83 on a base 80. By this head, a signal is written in on a record medium and a signal is read in a record medium. A part for the sensor of the reproducing head and the magnetic gap of a recording head are forming in the position piled up on the same slider in this way, and can do positioning for the same truck simultaneously. This head was processed into the slider and it carried in the magnetic recorder and reproducing device.

[0054] In this example, the upper part and the lower magnetic film of a recording head of an inductive mold were formed by the following processes.

[0055] The amount of nickel++: Set to the plating bath containing the usual stress relaxation agent and the surfactant, including 16.7 g/l and amount [ of Fe++ ]:2.4 g/l, and they are pH:3.0 and plating-current density:15 mA/cm2. The thin film magnetic head of the induction type which has - [ after carrying out frame plating on conditions ] lower magnetic core was produced. The width of recording track is 4.0 micrometers, and gap length is 0.4 micrometers. composition of this magnetic film -- 42.4 nickel-Fe (% of the weight) -- it is -- magnetic properties -- saturation magnetic flux density (BS) -- 1.64T and difficult shaft coercive force (HCH) -- 0.5Oe (s) -- specific resistance (rho) -- 48.1microomegacm it was . They are the up magnetic core 83, the lower magnetic core 84 which served both as the up shield layer, and a coil 87. It has the composition of the electrode 85 for passing sense current for the magnetoresistance-effect type element 86 for reproduction, and a magnetoresistance-effect type element, the lower shield layer 82, and a slider 80.

[0056] The performance (over-writing property) of the recording head by this invention evaluated by such composition is shown in drawing 9 . The outstanding record performance of about -50dB was obtained also in the RF field 40MHz or more.

[0057] Drawing 10 is 1.0Oe(s), if the relation of the difficult shaft coercive force of a magnetic film and the diameter of average crystal grain which were obtained by the galvanizing method acquired by this example and the sputtering method is shown and the diameter of crystal grain is made into 500A or less. It turns out that the following low coercive force is obtained.

[0058] Furthermore, the nickel-Fe alloy thin film which consists of 70 - 80 % of the weight of nickel and the remainder Fe by electroplating like ****, or this alloy thin film can also be formed in a lower magnetic film by sputtering using an alloy target.

[0059] Although cross section and drawing 12 of drawing 11 of a recording head of this invention are the plan, this thin film head consists of the lower magnetic film 83 and the up magnetic film 84 which consist of an up shield film 81 and the above-mentioned magnetic film to which it adhered on it. [ of an inductive mold ] Drawing 11 is the A-A cross section of drawing 12 . It adheres to the nonmagnetic insulator 89 among layers 83 and 84. Some insulators specify a magnetic gap 88 and this interacts by the magnetic medium put on the air bearing relation for example, by common knowledge technology, and the conversion relation. The base material 80

has the form of a slider where it has an air bearing front face (ABS), and this approaches the medium of the disk which rotates during disk file operation, and has a surfacing relation.
[0060] The thin film magnetic head has the back gap 90 made by the upper part 83 and the lower magnetic film 84. The back gap 90 is separated from the magnetic gap with the intervening coil 87.
[0061] The continuous coil 87 is the layer made on the lower magnetic layer 84 with plating, and carries out the electromagnetic coupling of these. There is electric contact 91 in the center of the coil with which the coil 87 is fill uped with the insulator 89, and there is a zone same and still bigger as electric contact 92 to the heel end point of a coil. The contact is connected to the external electric wire and the reading write-in signal-processing head circuit (illustration abbreviation).
[0062] In this invention, the cross section becomes large gradually as the coil 87 made from the single layer has the ellipse form distorted a little, arrangement of the portion with the small cross section will be carried out most soon at a magnetic gap and the distance from a magnetic gap becomes large.
[0063] The back gap 90 is carrying out the position relatively [ ABS / of a magnetic gap ] soon. However, several ellipse form many coils are comparatively densely contained between the back gap 90 and the magnetic gap 88, and the width of face or the cross-section diameter of a coil is small in this zone. Furthermore, the big cross-section diameter in the furthest portion from a magnetic gap brings about reduction in electric resistance. Furthermore, an ellipse (ellipse) form coil has neither an angle nor a sharp corner nor an edge, but has little resistance to current. Moreover, elliptical has few overall lengths of a conductor compared with a rectangle or a circular (annular) coil, and ends. As a result of these advantages, there is comparatively little total resistance of a coil, there is little generation of heat, and moderate thermolysis nature is obtained. In heat, by considerable-amount ******'s, layer collapse of a thin film layer, extension, and expansion are prevented, and the cause of the ball chip protrusion by ABS is removed.
[0064] The ellipse form coil configuration where change of width of face progresses to homogeneity mostly can adhere with the conventional plating technology cheaper than sputtering, vacuum evaporationo, etc. With the coil of a form with other configurations, especially an angle, plating adhesion tends to become the structure of uneven width of face. Removal of an angle or the sharp edge section gives only few mechanical stress with the done coil.
[0065] In this example, the wound coil was mostly formed between magnetic cores with elliptical, the diameter of a coil cross section is spreading gradually towards the back gap from the magnetic gap, a signal output increases and generation of heat decreases.
[0066] Drawing 13 is a conceptual diagram showing the composition on the base side of the magnetoresistance-effect element of this invention formed in the lower part of the above-mentioned inductive head. The magnetoresistance-effect film 110 is formed on a base 150 along the field 163 which opposes a record medium at the long strip of paper of the width of face 143 of an element. A convention of this configuration is effective in giving a moderate shape anisotropy in the perpendicular direction to the direction 160 which the magnetic field which should be sensed on the magnetoresistance-effect film 110 requires. On the magnetoresistance-effect film 110, resistance change produced by the magnetic field concerning a part for the magnetic field sensor which has the size of the width of face 141 of a direction parallel to record-medium 191 front face and the width of face 142 of a perpendicular direction through current by the electrode 140 which comes to contact electrically is obtained as an output.
[0067] Although the edge of a magnetoresistance-effect element serves as a configuration exposed to the confrontation side with a record medium in this conceptual diagram, the yoke-like soft magnetic material which draws the magnetic field from a record medium is arranged from a confrontation side, and if it is made to combine with the magnetoresistance-effect element installed inside magnetically, the mechanical endurance of an element will increase. Magnetic-path resistance of a yoke can be decreased by making MR height of an element small especially, and sensitivity can be improved.
[0068] The magnetoresistance-effect element of this invention has composition like drawing 14 . On a base 150, the laminating of the magnetoresistance-effect film 110 132, i.e., a bias film, a

magnetic film 111, the nonmagnetic electric conduction film 120, a magnetic film 112, the nonmagnetic electric conduction membrane layer 120, the magnetic-film layer 111, and the bias film 131 is carried out, and it comes to join an electrode 140 electrically. Although, as for the element composition of drawing 12 , the electrode 140 is installed in the bottom of the bias film 131, this serves as an example of effective structure, when an insulator like nickel oxide is used for example, for an up bias film.
[0069] An electrode may form only in a part, other structures, for example, bias film, and may form an electrode 140 from on the. Or there is also the method of sticking to this directly using a conductive bias film, for example, FeMn, a CoPt film, etc., and forming an electrode.
[0070] Although current leads the magnetic film which impressed the anisotropy with this element strong against a bias film therefore, and the magnetic film which impressed the weak anisotropy on a uniaxial anisotropy, a shape anisotropy, or the soft film bias compared with the aforementioned anisotropy, it is having carried out the laminating by turns through the nonmagnetic electric conduction film so that a magnetic combination might not be produced mutually. The impression direction of the anisotropy is described especially below.
[0071] Drawing 15 is the conceptual diagram showing the example of anisotropy control of the magnetoresistance-effect element of this invention, and is the perspective diagram of the element portion shown by A-A' in drawing 14 . The bias films 131 and 132 impress the anisotropy by switched connection in the direction of the arrows 171 and 172 in drawing. The direction of the magnetic field which should sense the arrow 160 in drawing, and an arrow 161 show the direction of the 1 direction anisotropy guided to the magnetic film 111. The easy magnetization direction of the magnetic film 112 inserted into the nonmagnetic electric conduction film 120 is impressed in the direction of the arrow 162 in drawing by guidance of a uniaxial anisotropy. This is attained by impressing a magnetic field in the predetermined direction during growth of a magnetic film. The example of this view is an example which realized impression of an anisotropy by the bias film and the induced magnetic anisotropy. As a result, both the arrows 161 and 162 intersect perpendicularly mutually within a film surface. As compared with the size of the magnetic field which should be sensed, by making the anisotropy of a magnetic film 112 small for the anisotropy of a magnetic film 111 greatly, magnetization of a magnetic film 111 is mostly fixed to an external magnetic field, and only magnetization of a magnetic film 112 comes to react greatly to an external magnetic field. Therefore, magnetization of a magnetic film 111 is in the state of the easy shaft excitation with parallel magnetization and external magnetic field in the state of the difficult shaft excitation with perpendicular magnetization and external magnetic field conversely with the anisotropy 161 at the anisotropy of a magnetic film 112 to the magnetic field which furthermore starts in the direction of an arrow 160 and which should be sensed. While the above-mentioned response is made to a still more remarkable thing according to this effect, to an external magnetic field, with the direction as the starting point of an arrow 162, the state where an element drives by the difficult shaft excitation by rotation can be realized, and magnetization of a magnetic film 112 can prevent the noise accompanying excitation by magnetic-domain-wall movement, and can enable operation by the RF.
[0072] As example with the another magnetoresistance-effect element of this example, it is the example which realized impression of an anisotropy by the hard magnetism film of two kinds of different bias films, i.e., an antiferromagnetism film. On a base 150, the laminating of the antiferromagnetism film 132, a magnetic film 111, a nonmagnetic membrane 120, a magnetic film 112, and the hard magnetism film 133 is carried out, and it comes to connect an electrode. Each has stuck the antiferromagnetism film 132 and the hard magnetism film 133 to the two-layer magnetic film 111,112 separated by the nonmagnetic membrane, heat treatment among a magnetic field or magnetization processing is carried out in the directions 172 and 173 which were parallel and went direct to the direction 160 of the magnetic field which should be sensed, and magnetization of a magnetic film 111,112 is guided in the direction of an arrow 161,162, respectively. As for an antiferromagnetism film, a cobalt platinum alloy etc. is used, as for nickel oxide and a hard magnetism film. Even if reverse and the guidance direction of each magnetization has the reverse position of a hard magnetism film and an antiferromagnetism film, there is an equivalent effect.

[0073] The film which constitutes the magnetoresistance-effect element of this example was produced as follows by the RF magnetron sputtering system. In 3mm the atmosphere of a toll of argons, on a ceramic substrate and Si single crystal substrate with 1mm [ in thickness ], and a diameter of 3 inches, the laminating of the following material was carried out to order, and they was produced. The target of nickel oxide, cobalt, a nickel-20at% iron alloy, and copper was used as a sputtering target. addition of the cobalt to the inside of nickel-iron -- nickel-20at% -- the chip of cobalt has been arranged on an iron-alloy target Moreover, for addition of the nickel to the inside of cobalt, and iron, the chip of nickel and iron has been arranged on a cobalt target. The cascade screen impressed RF power to the cathode which has arranged each target respectively, it generated plasma, opened and closed every one shutter arranged for every cathode, and formed each class one by one in equipment. While impressing the magnetic field of about 50 oersteds in parallel with a substrate using two pairs of electromagnets which intersect perpendicularly in a substrate side at the time of film formation and giving the uniaxial anisotropy, the direction of the switched connection bias of a nickel oxide film was guided in each direction.
[0074] Guidance of an anisotropy was performed with two pairs of electromagnets attached near the substrate by adding a magnetic field in the direction which should be guided at the time of formation of each magnetic film. Or heat treatment among a magnetic field was performed near the Neel temperature of an antiferromagnetism film after multilayer formation, and the direction of antiferromagnetism bias was guided in the direction of a magnetic field.
[0075] Evaluation of the performance of a magnetoresistance-effect element carried out patterning of the film to the shape of a rectangle, and was performed by forming an electrode. It was made for the direction of the uniaxial anisotropy of a magnetic film and the direction of current of an element to become parallel at this time. Through current fixed between electrode terminals, electric resistance impressed the magnetic field in the direction perpendicular to the direction of current in the field of an element, measured the electric resistance of an element as voltage between electrode terminals, and has sensed it as magnetic-reluctance rate of change.
[0076] The property of an element was expressed with resistance rate of change and the saturation magnetic field in Table 1. The reproduction output as an element corresponds to the size of this resistance rate of change, and sensitivity corresponds to the smallness of a saturation magnetic field, respectively. that in which especially magnetic-resistance-element No.1-5 have good magnetic properties with 4% or more of resistance rate of change so that clearly from the result of Table 1 -- it is -- No. -- compared with 6 and 7, it excels in resistance rate of change Especially sample No.1, and 2 and 4 show 7% of high output from the good magnetic field sensitivity and the resistance rate of change 6 of about ten oersteds of saturation magnetic fields.
[0077]
[Table 1]

表1

| 試料 | 膜の構成／厚さ（Å） | 抵抗変化率(%) | 飽和磁界(Oe) |
|---|---|---|---|
| No. 1 | NiO/NiFe/Cu/NiFe/Cu/NiFe/NiO<br>300/ 60 /21/ 40 /21/ 60 /300 | 6.5 | 12 |
| 2 | NiO/Co/Cu/NiFe/Cu/Co/NiO<br>300/50/21/ 40 /21/50/300 | 7.2 | 13 |
| 3 | NiO/NiFe/Cu/NiFe/Cu/NiFe/Cu/NiFe/NiO<br>300/ 60 /21/ 40 /21/ 40 /21/ 60 /300 | 5.5 | 11 |
| 4 | NiO/Co/Cu/Co/NiFe/Co/Cu/Co/NiO<br>300/60/21/15/ 40 /15/21/60/300 | 7.5 | 16 |
| 5 | NiO/NiFe/Cu/NiFe<br>300/ 60 /21/ 40 | 4.5 | 15 |
| 6 | NiFe/Cu/NiFe/NiO<br>60 /21/ 40 /300 | 3.0 | 14 |
| 7 | NiFe/Cu/NiFe/FeMn<br>60 /21/ 40 /150 | 3.9 | 10 |

[0078] In the magnetic storage in this example, although the field inserted into the electrode 85 of a couple became regenerative-track width of face, this could be 2 micrometers. At the time of record, the number of turns passed the current of 15mAop(s) in the coil 87 of 20, and recorded

arbitrary information on the medium magnetic layer, on the other hand, the 8mA direct current was impressed to lead wire at the time of reproduction, and the disclosure magnetic field from a medium magnetic layer was detected.

[0079] For the coercive force of the direction of a record bit, 2100 oersteds and a coercive force orientation ratio are this magnetic head 1.2 3.5 which uses CoCrTa (the addition of Cr is 16 atomic %) as a record layer Magnetic storage was constituted combining the magnetic disk of an inch. In addition, product Br-delta of the residual magnetic flux density of a magnetic-disk record layer and thickness which were used here is 100 gauss andmum. The specification of the magnetic storage constituted by this example is shown in Table 2.

[0080]

[Table 2]

表　2

録再分離型ヘッドを用いた３．５インチ装置仕様

| | |
|---|---|
| 記憶容量(フォーマット時) | ５．５ＧＢ |
| ディスク枚数 | ４ |
| データ面数 | ８ |
| ヘッド数 | ８ |
| トラック数／ディスク面 | ７３７８ |
| 最大線記録密度 | １７０ｋＢＰＩ |
| トラック密度 | ８．３ｋＴＰＩ |
| 回転数 | ４４９１ＲＰＭ |
| 記録周波数 | ８０．０ＭＨｚ |
| 転送速度(to／from Media) | １８ＭＢ／sec |

[0081] (Example 2) Drawing 6 shows the relation between composition and magnetic properties of the magnetic film which changed and galvanized various the metal ion concentration of nickel++ of a plating bath, i.e., the amounts, and the amounts of Fe++, and specific resistance (rho). nickel++ used NiCl2.6H2O, and Fe++ used FeSO4.7H2O, in addition the usual stress relaxation agent and the surfactant were added. pH: 3.0, the degree of bath temperature: It galvanized on condition that 30 degrees C and plating-current density:15 mA/cm2. Thickness is 3.0 micrometers.

[0082] It turns out that the property was excellent in saturation magnetic flux density (BS) with 1.5 or more, and membranous nickel content was [ property ] excellent in specific resistance (rho) with more than double precision as compared with 80 nickel-Fe permalloy film with which saturation magnetic flux density (BS) is known more than with 1.5T, and specific resistance (rho) is conventionally known for 38 - 60% of the weight of the range well with 40 or more microomegacm is shown. Moreover, difficult shaft coercive force (HCH) is as small as 1 or less Oe almost like 80 nickel-Fe permalloy film. Although the inclination of saturation magnetic flux density (BS) and specific resistance (rho) is almost the same compared with the value of bulk material, the amount which falls as nickel content increases is small. This is because the diameter of crystal grain is as remarkable as 40-80A and small compared with bulk material.

[0083] Such a property is plating-current density to 2.5 to about 3.5 about pH 5 - 30 mA/cm2 Even if changed into the range, there was no big change. Although changed into the range of 25-35 degrees C also about the degree of bath temperature, nickel content was not what influences the property itself in the grade which increases a little, so that temperature became high.

[0084] Although the magnetic film in this example is suitable for the combination using the Fe-nickel system alloy which contains 70 - 80 % of the weight of nickel in the up magnetic core of the inductive mold thin film magnetic head, and the lower part, it can use also for both of a vertical magnetic core.

[0085] As especially shown in drawing 16 , it is BS in 40 - 50 % of the weight of nickel. 1.6T That in which the highest value is shown and a membranous ratio (nickel/Fe) has the combination of nickel and Fe of 0.667-1.00 is desirable. In addition, the ratios (nickel/Fe) of the film in 38 - 60 %

of the weight of nickel are 0.613-1.50.
[0086] (Example 3) Drawing 17 is as a result of [ about the magnetic properties and specific resistance (rho) of the magnetic film which made the system (nickel44 % of the weight-Fe) alloy contain Mo ] examination.
[0087] That is, the magnetic properties and specific resistance (rho) of a magnetic film at the time of adding Mo as an element which makes specific resistance (rho) increase to the plating bath containing amount [ of nickel++ ]:16.7 g/l and amount [ of Fe++ ]:2.2 g/l are shown. Mo is Na2MoO4.4H2O. A maximum of 5 g/l addition was used and carried out. By adding Mo shows that the specific resistance (rho) of a magnetic film increases in proportion to an addition. For example, the specific resistance (rho) of a magnetic film shows the value of 3 times or more of about 60 or more microomegacm and 80 nickel-Fe permalloy film by addition Mo:2% of the weight. Then, saturation magnetic flux density (BS) stops at 1.50T and about 5% of fall about, and is 1.5 of 80 nickel-Fe permalloy film. The value beyond twice is maintained. however -- if an addition becomes 3% of the weight or more (Mo is 5 or more g/l at Na2MoO4.4H2O) -- coercive force (HCH) -- 1 or more Oes -- a bird clapper -- ** -- saturation magnetic flux density (BS) -- 1.5T It becomes the following and is not desirable.
[0088] Although Cr was also examined instead of Mo, the effect was the same as that of Mo almost.
[0089] The magnetic film in this example as well as the above-mentioned example can be used.
[0090] (Example 4) Drawing 18 is as a result of [ at the time of similarly adding Co and Mo ] examination in order to increase further saturation magnetic flux density (BS) and specific resistance (rho), without spoiling the magnetic properties of the 15 % of the weight-Mo magnetic film of (nickel44 % of the weight-Fe)-Co(es). In addition of Co, it is CoSO4-. Addition of Mo used Na2MoO4.4H2O like the example 3 using 7H2O. It is an example at the time of presupposing that the addition of Co is fixed 13% of the weight (it is 100 g/l at CoSO4.7H2O), and Mo was added to 4 % of the weight to this. Consequently, the saturation magnetic flux density (BS) of a magnetic film is 1.78T by adding Co 13% of the weight. Although it increases about 10%, specific resistance (rho) will be reduced 35microomegacm and about 30%. Therefore, by adding Mo, specific resistance (rho) is recovered and is 2.5. Specific resistance (rho) serves as about 55 microomegacm by weight % addition, and about 20% of increase is shown conversely. Saturation magnetic flux density (BS) is 1.55T then. A high value is shown compared with a film without Co. Moreover, since addition of Co increases a membranous anisotropy field, there is in the direction stable also in magnetic properties.
[0091] The magnetic film in this example as well as the above-mentioned is applicable.
[0092] (Example 5) Drawing 19 is the result of measuring the frequency characteristic of the permeability (mu) of the typical magnetic film produced by the manufacture method shown in examples 2-4, and standardizing with each value of mu of 1MHz. It measured also about 80 nickel-Fe permalloy as a comparison sample. All thickness is 3 micrometers. It turns out that frequency (f) when the thing of 48 - 60microomegacm of the specific resistance in this example makes the fall to the frequency (f) of permeability (mu) 25% (namely, 75% of initial value) is extended about 3 to 5 times compared with 40MHz - 70MHz and 15MHz of a permalloy, and the frequency characteristic is improving.
[0093] (Example 6) Drawing 20 and drawing 21 are the cross sections of the induction-type thin film magnetic head which has the two-step coil used for the upper part and the lower magnetic film like the example 1 as a magnetic film concerning this invention. As shown in drawing, this thin film magnetic head 210 contains the lower part and the up magnetic film which were formed from the layers 212 and 214 of two sheets of magnetic materials, such as a permalloy. It adheres to layers 212 and 214 in two stages which contain the plastic surgery layers 211 and 213, respectively. These layers 212 and 214 are separated by insulating layers 215,126 and 217 except for the posterior part gap field 218 which touches physically, and the proximal region 219 separated by the thin film 220 of a non-magnetic material in order to form a magnetic gap 221. The flat electric conduction coil 222 is formed in the layer 212 of the magnetic substance, and the space between 214. The coil 222 has two or more volume 223a in the layer of two sheets to which it adhered by the ellipse form pattern between the layer 215,216 of an insulating material,

and 217, or 223n. The edge of the gap 221 for conversion is in agreement with the air bearing side (ABS) formed on the substrate 224 of the non-magnetic material to which the above-mentioned layer is made to adhere. The gap 221 for conversion interacts by a magnetic-recording medium (not shown) and air bearing relations, such as a rotating magnetic disk. When a disk rotates, the head flies the air bearing side (ABS) very near the disk recording surface.
[0094] In order to manufacture this thin film magnetic head and to give the thin adhesion layer of the pole piece proximal region 219, a magnetic layer 212 and the plastic surgery layer 211 are adhered on a substrate 224 using a suitable mask. And except for the portion of the posterior part gap field 218, it adheres to a non-magnetic layer 220 on a layer 211 and 212. And except for the place of a magnetic gap 221, it adheres to the 1st insulating layer 215 above a layer 220. Electroplating adheres to coil 223a of the shape of an ellipse swirl of the 1st layer of a continuous and flat conductor, or 223n on an insulating layer 215. It adheres to an insulating layer 216 above the 1st layer of a coil, adheres to the coil of the 2nd layer of a coil, and adheres to an insulating layer 217 above the coil. And except for the place of the posterior part gap field 218 which contacts a magnetic layer 212 physically, it adheres to a magnetic layer 214 above the insulated coil as above-mentioned.
[0095] The nose of cam 219 of a pole piece has the width of face W of the simultaneously regularity chosen beforehand. It is somewhat narrow in whether this width of face W is almost the same as the width of face of the truck on the corresponding magnetic medium which can be rotated. The step which the width of face W which the pole piece nose of cam chose is obtained by cutting off a pole piece nose of cam, and cuts off the pole piece nose of cam is performed before the step which adheres the plastic surgery layer 213 for the 2nd magnetic layer 214. Thus, if a process is changed, cutting at the nose of cam of a pole piece will become possible in a precision far higher than the conventional process.
[0096] After adhering a magnetic layer 214, and before adhering the plastic surgery layer 213, a thin-film-head assembly is covered with the photoresist mask 230. And by the either side of the pole piece proximal regions 219 of the head, a window (aperture) 232 is formed into a photoresist mask. The head by which the mask was carried out receives an ion MIRINDA process. The portion which has not carried out the mask of in process [ the ] and the head is etched, and it cuts off to the width of face of a request as shows a pole piece nose of cam to drawing 5 .
[0097] An ion MIRINDA process has the almost same influence as usual on the field processed, and it is made for this to also make the head structure which has not carried out a mask with the mask of a photoresist etch. This carries out the reattachment of the matter etched from the head again to the head structure where it was etched on the portion of the remainder of the mask, and in front of it. From this reason, an ion milling process is performed in two stages. At the 1st step, the head structure which has not carried out a mask is etched to a substrate 224 through a magnetic layer 14, the nonmagnetic gap layer 220, and a magnetic layer 212. In order to remove this material completely, as for the 1st step, it is desirable to perform to the grade which etches too much for a while into a substrate 224. The 2nd step in this ion milling process is prepared in order to remove all reattachment matter, for example, it receives perpendicularly, and is performed at the big angle of 75 - 80 degrees. In the example with a suitable ion milling step, the etching speed for the permalloy magnetic material of about 550A is obtained per minute by about 2W [ per 1 cubic centimeter ] power flux density. A photoresist is removed, it adheres to the plastic surgery magnetic layer 213, and the thin film magnetic head is completed.
[0098] This photoresist mask is etched into an ion milling process, and the thickness of the resist of the upper part of this head becomes thinner than the thickness of the photoresist above a pole piece field according to the appearance of a magnetic layer 214.
[0099] The thin film magnetic head manufactured by this invention is the yoke structure of having a posterior part gap field at the end at the magnetic gap for conversion (transducer), and the other end, and is the composition of having made the above-mentioned yoke structure of having the electric conduction coil for energizing a magnetic yoke to which it adhered between the magnetic gap of the yoke structure, and the posterior part gap field forming in the layer of the magnetic material of two sheets.
[0100] The magnetic storage constituted using the thin film magnetic head produced by this

example is described. For the magnetic disk unit by this example, an outer diameter is about 3.5 as mentioned above. It has the spindle for rotating the magnetic disk of an inch, and a disk, the positioning mechanism of the magnetic head, and housing. one's record reproduction type head to which the magnetic head used the induction-type element for record reproduction -- it is -- the width of recording track -- 5.0 micrometers it is . the upper part and the lower magnetic film of a head -- saturation magnetic flux density -- 1.3 a tesla -- rho= 60micro omegacm of specific resistance, relative permeability mu= 1000, and the (nickel44 % of the weight-Fe) -2-% of the weight Mo alloy thin film of d= 3 micrometers of thickness -- using -- gap length -- 0.4 micrometers it is . In addition, in the magnetic pole of a head, saturation magnetic flux density is 1.6T. An equivalent effect can be acquired even if it uses the thin film which contains ZrO2 whose particle size is 2nm - 3nm, Y2O3, TiO2, HfO2 and aluminum 2O3, or SiO2 in the same plating thin film of a nickel-Fe system alloy or Fe-Co-nickel/aluminum2O3 / Fe-Co-nickel multilayer, and a nickel-Fe thin film. In addition, when making the oxide in a magnetic film mix, this particle size is 0.5nm - 5nm. Between is desirable. This is because only the specific resistance of a magnetic film can be raised without following saturation magnetic flux density or the remarkable fall of ********** within the limits of this particle size. In addition, while specific resistance increases up to about 60 microomegacm by making a Fe-nickel alloy thin film contain the above oxides, relative permeability shows good ********** 1000 order. On the other hand, when applying the NiFe thin film which does not contain an oxide to the record magnetic pole of a head, a RF property can be improved by lowering relative permeability to 500 or less. However, the record magnetomotive force of a head is 0.5ATs in this case. It is necessary to set up above.

[0101] For the coercive force of the direction of a record bit, in the record layer of a magnetic disk (11), 2100 oersteds and a coercive force orientation ratio are 1.2. CoCrTa (the addition of Cr is 16at(s)%) is used. Product Br-delta of the residual magnetic flux density and thickness in this magnetic disk is 300 gauss andmum. By using this record medium, it becomes possible to reduce sharply the improvement in a track-recording-density property, and the medium noise in a high track-recording-density field. In addition, a bit error rate decreases that medium coercive force is 200 or less oersteds, and equipment operating becomes impossible.
[0102] The rotational frequency of the spindle at the time of record reproduction is 4491rpm. It is set up and the flying height of the head in the data storage area outermost periphery on the magnetic disk at this time is 0.05 micrometers. It is set up so that it may apply to the outermost periphery from the most inner circumference of a data storage area and the track recording density on each truck may become equal, and it sets to the outermost periphery, and record frequency is 67.5MHz. It is set up.
[0103] In the magnetic disk unit in this example, the track recording density of the data on each truck is set as 144kBPI(s) (kiro Bit Per Inch), track density is set as 5kTPI(s) (kiloTrack Per Inch), and field recording density is 720 megabits per 1 square inch. Four magnetic disks are used in this example, and the format capacity of equipment is 2.8. GIGABAITO and data transfer speed are 15 megabytes in 1 second. In addition, although data are recorded using 8/9 conversion, even if it records data using one to 7 conventional method, the equipment which has a performance equivalent to this example can consist of this examples. However, the record frequency in this case is set to 45MHz.
[0104] The specification of the magnetic storage constituted by this example is shown in Table 3.
[0105]
[Table 3]

表　３

３．５インチ装置仕様

| | |
|---|---|
| 記憶容量(フォーマット時) | ２．８ＧＢ |
| ディスク枚数 | ４ |
| データ面数 | ８ |
| ヘッド数 | ８ |
| トラック数／ディスク面 | ４４２７ |
| 最大線記録密度 | １４４ｋＢＰＩ |
| トラック密度 | ５ｋＴＰＩ |
| 回転数 | ４４９１ＲＰＭ |
| 記録周波数 | ６７．５ＭＨｚ |
| 転送速度(to／from Media) | １５ＭＢ／sec |

[0106] (Example 7) Next, the diameter of a disk is 2.5 inches, 1.8 inches, and 1.3. The result which constituted magnetic storage combining the magnetic head according the magnetic disk which is an inch to this invention is described. In addition, the magnetic head used by this example and the magnetic disk are the same as what was used in the example 6, the track recording density of the data on each truck is set as 144kBPI(s), and track density is set as 5kTPI(s). In addition, for the rotational frequency of a spindle, it sets in each diameter of a disk, and transfer rates are 15 MB/sec. It has set up so that it may become. Moreover, as the example 6 has described, even if it records data using one to 7 conventional method, each equipment which has a performance equivalent to this example can be constituted. However, the record frequency in this case is set to 45MHz. The specification of each equipment is described in Table 4 - 6.
[0107]
[Table 4]

表　４

２．５インチ装置仕様

| | |
|---|---|
| 記憶容量(フォーマット時) | １．８ＧＢ |
| ディスク枚数 | ４ |
| データ面数 | ８ |
| ヘッド数 | ８ |
| トラック数／ディスク面 | ２９５１ |
| 最大線記録密度 | １４４ｋＢＰＩ |
| トラック密度 | ５ｋＴＰＩ |
| 回転数 | ６７３６ＲＰＭ |
| 記録周波数 | ６７．５ＭＨｚ |
| 転送速度(to／from Media) | １５ＭＢ／sec |

[0108]
[Table 5]

表 5

1.8インチ装置仕様

| | |
|---|---|
| 記憶容量(フォーマット時) | 1.4GB |
| ディスク枚数 | 4 |
| データ面数 | 8 |
| ヘッド数 | 8 |
| トラック数/ディスク面 | 2213 |
| 最大線記録密度 | 144kBPI |
| トラック密度 | 5kTPI |
| 回転数 | 8982RPM |
| 記録周波数 | 67.5MHz |
| 転送速度(to/from Media) | 15MB/sec |

[0109]
[Table 6]

表 6

1.3インチ装置仕様

| | |
|---|---|
| 記憶容量(フォーマット時) | 0.9GB |
| ディスク枚数 | 4 |
| データ面数 | 8 |
| ヘッド数 | 8 |
| トラック数/ディスク面 | 1475 |
| 最大線記録密度 | 144kBPI |
| トラック密度 | 5kTPI |
| 回転数 | 13473RPM |
| 記録周波数 | 67.5MHz |
| 転送速度(to/from Media) | 15MB/sec |

[0110] (Example 8) Two kinds of induction-type thin film magnetic heads using the magnetic pole from which specific resistance rho, Thickness d, and relative permeability mu differ were produced, and the frequency dependence of each record magnetic field strength was measured using the electron ray tomography method. The relative permeability mu in the magnetic pole material of each head made as an experiment, magnetic pole thickness d, specific resistance rho, and a low frequency field 1MHz or less is as being shown in Table 7.
[0111] Head A uses for the magnetic pole the nickel-Fe alloy monolayer which has composition of a publication in the example 1 of 3 micrometers of thickness. Head B is 2.2 micrometers of thickness like an example 4. About an Fe-Co-nickel-Mo film, it is aluminum 2O3 of 0.1 micrometers of thickness. The magnetic pole which carried out the laminating through the interlayer is used. therefore, the total magnetic pole thickness of this head -- 4.5 micrometers it is . In addition, for the 2O3/Fe-Co-nickel-Mo multilayer of Fe-Co-nickel-Mo/aluminum used here, the thickness of an Fe-Co-nickel-Mo film monostromatic is 2.7 micrometers. If it becomes above, the magnitude of attenuation of the magnetic field strength in the record frequency of 45MHz becomes [ reach to 10% or more, write in connection with record frequency, and ] the cause of change of the amount of bleeding, and an over-writing film and is not desirable. At this example, it is 2.2 micrometers about the thickness of a Fe-Co-nickel film monostromatic. It set up. As for one side and Head C, specific resistance uses [ thickness ] the Co-Ta-Zr amorphous monolayer of 90microomegacm for the lower magnetic film of a magnetic pole by 3 micrometers.
[0112]
[Table 7]

表 7

試作した薄膜磁気ヘッド諸元

| ヘッド | 磁極材料 | 磁極厚みd（μm） | 比抵抗ρ（μΩcm） | 比透磁率μ |
|---|---|---|---|---|
| A | NiFe | 3.0 | 16 | 1000 |
| B | FeCoNiMo多層膜 | 2.2 | 16 | 1000 |
| C | CoTaZr | 3.0 | 90 | 1000 |

[0113] The head efficiency eta was computed from the measurement result of the frequency dependence of the standardized record magnetic field strength. It hits, shell record magnetic field strength falls, and the intensity exceeding 10MHz in 100MHz is decreasing the head A which uses a nickel-Fe monolayer as a magnetic pole about 60% or less of the intensity in a low frequency field. On the other hand, although Head B is using the Fe-Co-nickel-Mo film equivalent to the NiFe film which permeability and specific resistance use for Head A, since it has multilayered through 2Oaluminum3 insulating layer, the eddy current loss is eased sharply. As for the magnitude of attenuation of the magnetic field strength in 100MHz, in the case of this head, about 20% and the frequency characteristic are improved. Moreover, also in 100MHz, as for Head C, the frequency characteristic which was excellent in the magnitude of attenuation of magnetic field strength with about 0 is obtained.

[0114] (Example 9) In this example, the upper part and the lower magnetic film were formed by the following processes.

[0115] The amount of nickel++: Set to the plating bath containing the usual stress relaxation agent and the surfactant, including 16.7 g/l and amount [ of Fe++ ]:2.4 g/l, and they are pH:3.0 and plating-current density:15 mA/cm2. The thin film magnetic head of the induction type which has - [ after carrying out frame plating on conditions ] lower magnetic core was produced. The width of recording track is 4.0 micrometers, and gap length is 0.4 micrometers. composition of this magnetic film -- 42.4 nickel-Fe (% of the weight) -- it is -- magnetic properties -- saturation magnetic flux density (BS) -- 1.64T and difficult shaft coercive force (HCH) -- 0.5Oe (s) -- specific resistance (rho) -- 48.1microomegacm it was .

[0116] Perspective diagram and drawing 23 of drawing 22 of record / reproduction discrete-type thin film magnetic head are the plan of a recording head. It has the up magnetic core 320, the lower magnetic core 321 which served both as the up shield layer, and a coil 325, and the

recording head consists of these three. It has the electrode 324 for passing sense current for the magnetoresistance-effect type element 323 for reproduction, and the magnetoresistance-effect type element 323, and the lower shield layer 322, and has the composition of a slider 326.
[0117] It carried in the magnetic disk unit which shows the thin film magnetic head of this induction type to an example 1, and the record performance was evaluated. For a medium, an outer diameter is 3.5. An inch and coercive force are 2500Oe(s). As for the performance (over-writing property) of the recording head by this invention evaluated by such composition, the outstanding record performance of about -50dB was obtained also in the RF field 40MHz or more.
[0118] (Example 10) The magnetic storage in this example uses the record reproduction separation head which used the magnetoresistance-effect type element (MR element) for reproduction for record shown in drawing 22 using the recording head of an induction type. In the up shield layer 81 which served as another record magnetic pole while forming the up magnetic film of the record magnetic pole of an inductive mold head as mentioned above, it is 2.2 micrometers about the thickness of a Fe-Co-nickel film monostromatic. The 2O3/Fe-Co-nickel multilayer of Fe-Co-nickel/aluminum carried out is used. In addition, aluminum 2O3 The width of recording track of 0.1 micrometers and a record magnetic pole set an interlayer's thickness to 3 micrometers. The nickel-Fe alloy whose thickness is 1 micrometer was used for the lower shield layer 82. The nickel-Fe alloy whose thickness is 15nm is used for the magnetoresistance-effect type element 86, and this is driven using a soft film bias method. In addition, the multilayer system huge magnetoresistance-effect element of the alloy system huge magnetoresistance-effect element [, such as the spin bulb type element which consists of an antiferromagnetism film of a nickel-Fe layer, Cu layer Co layer and an nickel-O system, a Fe-Mn system, or a Cr-Mn system instead of or Co-Ag, Co-Au, NiFe-Ag, Co-Cu, and Fe-Ag, ] or Co/Cr, Fe/Cr, Co/Cu, and NiFe/Cu system can also be used for the magnetoresistance-effect type element 86. [ a nickel-Fe alloy ]
[0119] The magnetic storage constituted by this example can attain the same specification as the above-mentioned table 2.
[0120]
[Effect of the Invention] According to this invention, also as opposed to a high coercive force medium, 15 or more MB/s of recording head media transfer rates sufficiently recordable also in a RF field is secured by the low cost frame galvanizing method by specific composition, and it is 4000rpm about the record frequency of 45MHz or more, and a magnetic disk. The high recording density magnetic storage fast transmission of data, shortening of the access time, and whose increase of storage capacity are attained is obtained by making it rotate at the above high speed.

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[Translation done.]

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] The perspective diagram of a magnetic recording medium.
[Drawing 2] The cross section of a magnetic recording medium.
[Drawing 3] Front view of a magnetic recording medium.
[Drawing 4] The plan of a magnetic recording medium.
[Drawing 5] Assembly drawing of the magnetic head and means for supporting.
[Drawing 6] Assembly drawing of the magnetic head and means for supporting.
[Drawing 7] The perspective diagram of the slider with which the thin film magnetic head was prepared.
[Drawing 8] The perspective diagram of the record reproduction discrete-type thin film magnetic head.
[Drawing 9] The diagram showing the relation between frequency and over-writing.
[Drawing 10] The diagram showing the relation between the diameter of crystal grain, and the coercive force in difficult shaft orientations.
[Drawing 11] The cross section of the induction-type thin film magnetic head.
[Drawing 12] The plan of the induction-type thin film magnetic head.
[Drawing 13] The plan showing the film composition of the magnetoresistance-effect type thin film magnetic head.
[Drawing 14] Drawing showing the film composition of a magnetoresistance-effect type head.
[Drawing 15] Drawing showing the film composition of a magnetoresistance-effect type head.
[Drawing 16] The diagram showing the relation between BS, and rho and HCH. [ the amount of nickel or (nickel/Fe) a ratio, and ]
[Drawing 17] The diagram showing the relation between BS, and rho and HCH. [ the amount of Mo, and ]
[Drawing 18] The diagram showing the relation between BS, and rho and HCH. [ the amount of Mo, and ]
[Drawing 19] The diagram showing the relation between frequency and (1MHz of mu f/mu).
[Drawing 20] The plan of the thin film magnetic head.
[Drawing 21] The cross section of the thin film magnetic head.
[Drawing 22] The perspective diagram of the record reproduction discrete-type thin film magnetic head.
[Drawing 23] The plan of the induction-type thin film magnetic head.
[Description of Notations]
1 [ -- A pointing device, 25 / -- A slider, 80 / -- A base (slider) 81,321 / -- An up shield film, 82,322 / -- A lower shield film, 83,320 / -- An up magnetic film, 84 / -- A lower magnetic film, 85,324 / -- An electrode, 86,110,323 / -- A magnetoresistance-effect film, 87,222,325 / -- A coil, 88,221 / -- A magnetic gap, 89 / -- An insulator, 90 / -- Back gap. ] -- A magnetic disk, 2 -- thin film magnetic head, 3 -- Gimbal

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[Translation done.]